Quantitative Side-Scan Research for Sediment Characterization

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LONG-TERM GOALS

The long-term goals of this work are to contribute to the understanding of bottom backscatter at high frequencies, provide techniques for determining sediment characteristics based on backscatter, and to support experiments within the context of the high-frequency, underwater communications and bottom scattering experiments such as KauaiEx and SAX04.

OBJECTIVES

Our main objective is to contribute to the understanding of seafloor backscatter at high frequencies. Additionally, in support of bottom scattering projects, another principal objective is to provide wide-area, high-resolution data to describe the nature of the bottom and to develop a means of classifying bottom characteristics based on backscatter signals. These objectives require an understanding of the statistical nature of the backscatter signal and how to delineate changes in the bottom based on changes in the statistics of backscatter through the collection of several data sets including KauaiEx and SAX04 data.

APPROACH

In September of 2005, we completed a side-scan survey off Fort Walton Beach in support of SAX04. We had run several lines including creation of standard seafloor images for the side-scan returns and logging quantitative digital, high-resolution, backscatter data taken simultaneously at 150 and 300 kHz. Part of our effort in FY05 included analyzing the data to help characterize the bottom in the SAX04 experiment area. Additionally, in this fiscal year, we analyzed quantitative data taken in several other surveys in 2003 and 2004. Our approach for analyzing these data was based on the evaluation of probability density functions (PDFs) of the backscattered signals. In addition to seeking a fundamental understanding of the relationship between backscattering and the PDFs it produces, we attempt to develop means for classifying the seafloor and delineating changes in the seafloor based on these PDFs.

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14. ABSTRACT
The long-term goals of this work are to contribute to the understanding of bottom backscatter at high frequencies, provide techniques for determining sediment characteristics based on backscatter, and to support experiments within the context of the high-frequency, underwater communications and bottom scattering experiments such as KauaiEx and SAX04

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In mid-fiscal year, we were funded by DURIP through ONR (N00014-05-1-0750) to assemble a wide-swath geophysical subbottom profiler to augment the seafloor surface backscattering work we conduct with the side-scan sonar. The approach under that addition funding for this fiscal year is to develop detailed specifications and requests for quotes on the various subsystems required.

WORK COMPLETED

This new phase of work on quantitative side-scan sonar bottom scattering research began this fiscal year as a small three-year effort. It does, however, continue our longer term efforts that began about four years ago. What has been completed this fiscal year is the analysis of SAX04 data as well as analysis and comparisons with the analyses of data from past surveys. Algorithms for correcting and scaling the data as well and the development of standard procedures for the analysis of the PDFs were completed. Several algorithm for change in the seafloor were developed and tested, and demonstrated consistently to detect changes in backscattering that are barely visible to the eye. A simple test for the all-important Rayleigh distribution was developed and tested. This work has resulted in the publication of a paper in the proceedings of an acoustic conference in Bath, UK, [1], a student presentation at a meeting of the Mississippi Academy of Science [2],and contributed to a Masters student thesis [3] and a report for another ONR project [4].

Specifications and an RFQ were completed and bids were received for the towing system for the wide-swath geophysical subbottom profiler. A bidder has been selected for the construction of the towing system. Specifications and an RFQ for the data-collection subsystem are being prepared. Access to a government patent for a transmit/receive switch has been requested from NRL to be integrated into the data-collection subsystem. Three Neptune Sonar, LTD, T70 acoustic modules are in hand and ready to be integrated into the overall system. Beam pattern and steering algorithms for the 30 individual transducers have been developed.

RESULTS

The fundamental analytical techniques in this study are the calculation and analyses of PDFs of the backscattered signals of selected sub-regions of the seafloor and the delineation of changes in the seafloor based on these PDFs. A number of change-detection algorithms exist for detecting changes in bottom properties based on backscatter, but all are associated with textural analyses based on imagery rather than PDFs. Basing a change-detection algorithm on PDFs is important because all signal-processing algorithms for detection of foreign objects (e.g., mines) are based on decision theory involving PDFs. And, in particular, these target-detection algorithms are based principally on an assumption of Rayleigh reverberation statistics, which often is not the prevailing statistics. Any change in the background PDF of a region fundamentally changes the detection decision and, therefore, for such applications seafloor changes should be monitored by quantitative algorithms based on PDFs such as those developed in this project rather than on textural analyses. Coupling change-detection algorithms to PDFs has added advantages in that, as regions are delineated, PDFs can be improved iteratively by their proper groupings by regions.

The analytical methods for change detection for the above-mentioned backscatter research were based on algorithms using a modified Chi-Square goodness-of-fit Test (CST) developed earlier. This test is applied to a comparison of the PDF at hand to some ‘standard,’ which may be an overall PDF of the survey, some a priori known PDF, or a canonical PDF such as a Rayleigh distribution.

The CST is based on the algorithm

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